

The Giant Tides of Fundy

What are tides?

The tide is the natural change in elevation of water over time and can easily be observed along any ocean coastline. Some areas of the world have one high tide and one low tide every day, these are called diurnal tides. Other parts of the world have two high tides and two low tides every day, these are called semi-diurnal tides. Here in New Brunswick we have semi-diurnal tides and the highest tides in the world.

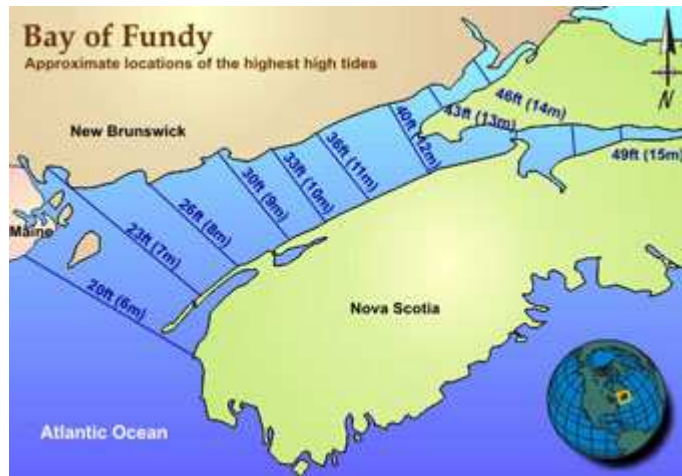
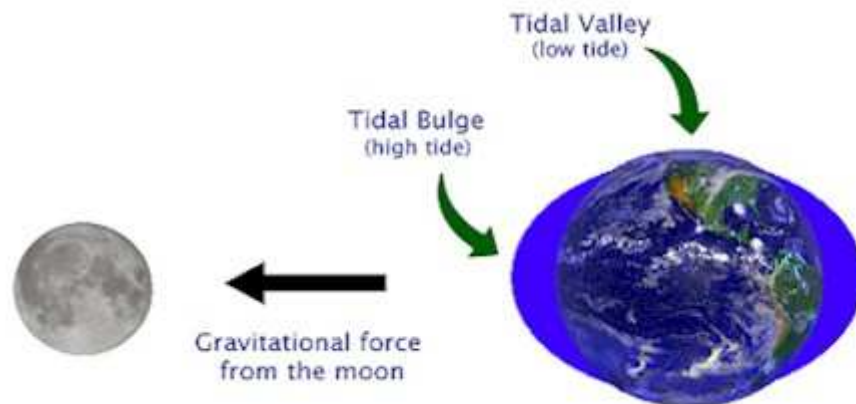


Image from NOAA National Weather Service page on [Fundy's tides](#).

What causes tides?

Tides are caused by the gravitational pull from the moon and the sun on water. Before the role of the moon and the sun are discussed, we need to know a little bit about gravity first. Any object that has a mass will have some gravitational pull towards its centre. Generally the more massive an object is, the larger its gravitational force will be. Gravity is also dependent on distance. The greater the distance between two objects, the smaller the gravitational force will be ($F = M_1M_2G/d^2$). Now that these two important rules have been addressed, the roles of the moon and sun can be described.

Although the sun has substantially more mass, the moon has the greatest effect on our tides because it is significantly closer to the earth than the sun. The moon's gravitational force pulls on the earth and creates two bulges of water, one on either side of the earth.



The bulge of water on the left side of the earth is created because that is the direction in which the moon is pulling. The bulge of water on the right side of the earth is formed because there is very little gravitational force being exerted on that side (furthest away from the moon) so the water doesn't get pulled around to the left side of the earth, but is left behind forming the second bulge.

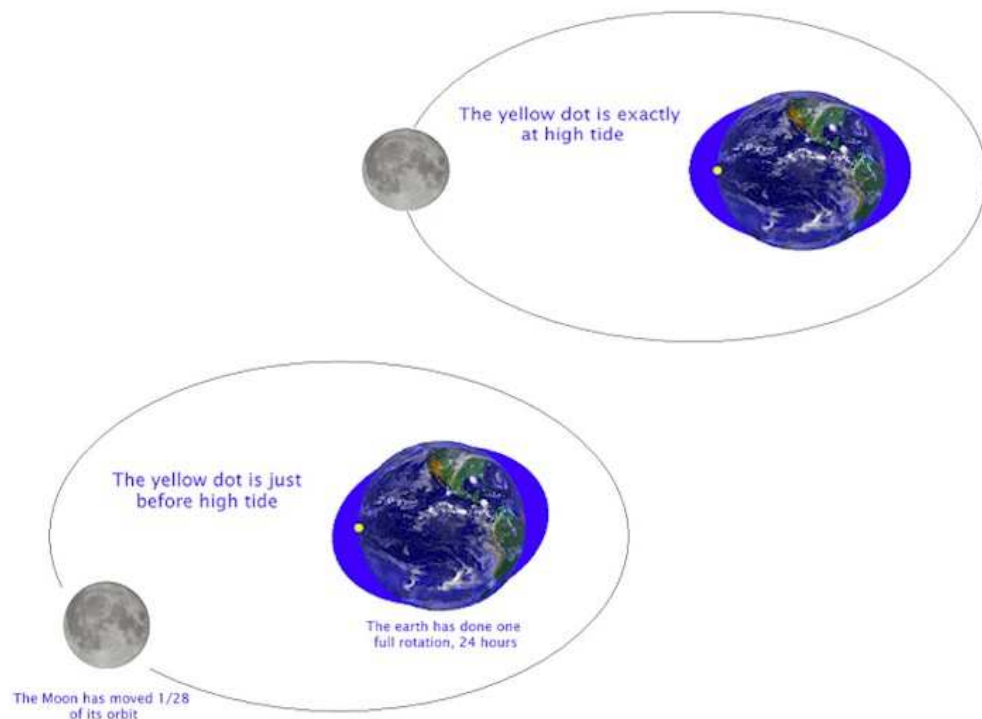
The areas on earth where the bulges are situated are our high tides and the areas halfway between the bulges (tidal valleys) are our low tides. As the earth rotates, it passes through these tidal bulges and tidal valleys creating the high tide and low tide we see every day. People often say, "the tide is coming in" when actually we should be saying "we are rotating into the tide"!

How long does it take for the tide to come in?

Here in the Bay of Fundy it takes 6 hours and 13 minutes for the tide to rise from dead low tide to full high tide. It also takes 6 hours and 13 minutes for the tide to drop from full high tide to dead low tide. There are four tides every day in the Bay of Fundy, two high tides and two low tides. Multiplying 6 hours and 13 minutes by four = 24 hours and 52 minutes, but how long is each day? 24 hours. Why is there an extra 52 minutes?

Why does the time of the tides vary from day to day?

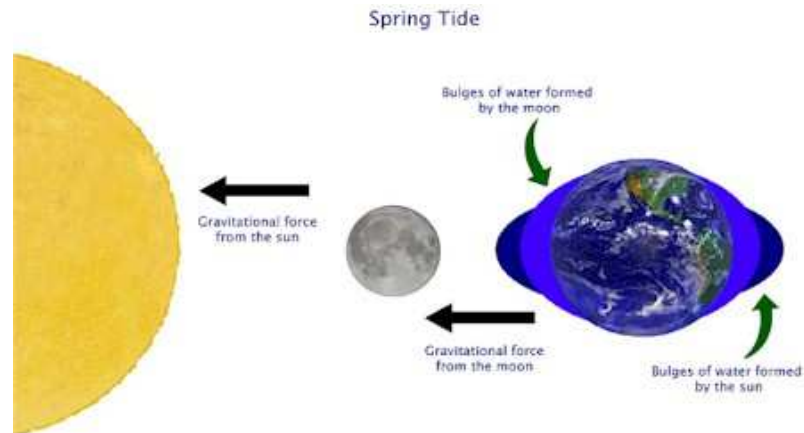
High tide and low tide are never at the same time every day. The time of the tide changes from day to day because of the revolution of the moon around the earth. It takes 28 days for the moon to travel around the earth and it takes 24 hours for the earth to make one full rotation. By the time the earth makes one rotation, the moon has moved a little further ($1/28$) along its orbit around the earth. This means that the bulges of water formed by the moon follow as well, as a result it takes approximately 1 hour or more accurately 52 minutes, for a specific spot on the earth to catch up to the high tide bulges. Therefore the time of high tide tomorrow will be approximately 1 hour later than the time of high tide today.



Why does the height of the tide vary from day to day?

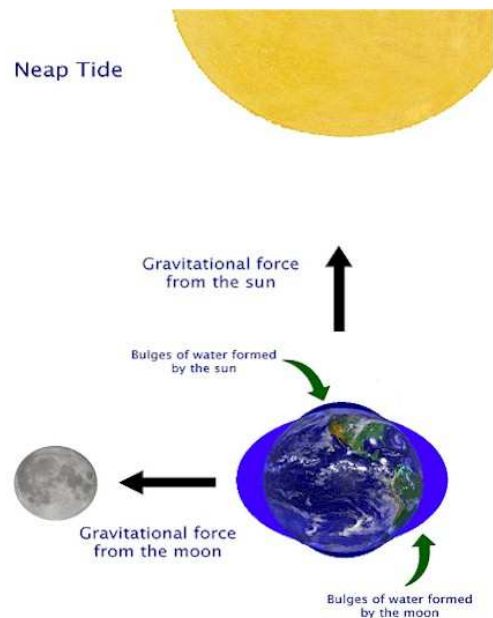
Have you ever walked along a beach and noticed the lines of seaweed at different heights along the shore? These lines are indicators telling us where the height of the last high tide has been, and the height of the previous days' high tides as well. The height of the tide is dependent on two major factors, one being the addition of the sun and the second being the distance of the moon away from the earth.

During a 'new moon' and a 'full moon' the sun, moon and earth are all in a line, as shown in the diagram.

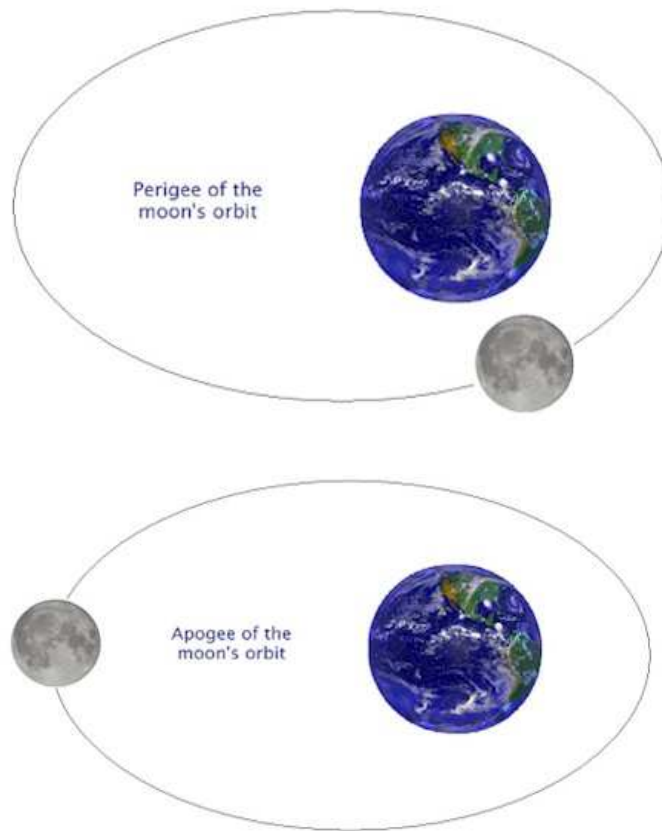


This means that the gravitational forces from both the moon and the sun are pulling along the same plane and will produce a bigger force, generating larger tidal bulges and deeper tidal valleys. When this occurs we get very high, high tides and very low, low tides.

These are known as 'spring tides' and will happen twice a month. During the 'half moon' phases, more specifically known as the '1st quarter' and '2nd quarter' moon phases, the sun and moon are pulling at right angles to one another as shown in the diagram. This will produce smaller tidal bulges toward the moon and shallower tidal valleys toward the sun. When this occurs we have low, high tides and high, low tides. These are known as 'neap tides' and will also happen twice a month.



The moon's orbit around the earth is not a perfect circle but rather elliptical in shape, shown in the diagrams.



As the moon orbits around the earth it travels closer or further away from the earth depending on its position in the orbit. As we already know the closer an object becomes, the stronger the gravitational force will be. Therefore when the moon is at its closest point to the earth, known as the perigee of the orbit, it will produce higher than usual tides because the stronger force pulls the tidal bulges out further. When the moon is at its furthest point from the earth, known as the apogee of the orbit, it will produce lower than usual tides because the weaker force will cause the tidal bulges to be smaller.

During any given month a combination of these factors produce varying heights of the tides. The earth's orbit around the sun is also elliptical therefore depending on whether the earth is at the apogee or perigee of its orbit we can be certain that the tides will be lower or higher depending on the season. Below is an example of a tide table.

**St. Andrews, Passamaquoddy Bay, New Brunswick
June 2006**

Date	High Tide		Low tide	
	Time	Height (m)	Time	Height (m)
June 1	4:20 am 4:54 pm	6.60 6.21	10:48 am 11:09 pm	1.02 1.59
June 2	5:12 am 5:46 pm	6.35 6.06	11:38 am	1.26
June 3 First Quarter Moon	6:04 am 6:39 pm	6.11 5.96	12:01 am 12:29 pm	1.76 1.47
June 4	6:58 am 7:31 pm	5.92 5.93	12:54 am 1:19 pm	1.87 1.65
June 5	7:51 am 8:20 pm	5.80 5.95	1:47 am 2:08 pm	1.90 1.76
June 6	8:42 am 9:06 pm	5.75 6.04	2:38 am 2:56 pm	1.87 1.82
June 7	9:30 am 9:50 pm	5.79 6.18	3:27 am 3:43 pm	1.75 1.80
June 8	10:16 am 10:33 pm	5.90 6.38	4:13 am 4:29 pm	1.56 1.72
June 9	11:01 am 11:17 pm	6.08 6.61	4:59 am 5:15 pm	1.32 1.57
June 10	11:46 am	6.28	5:44 am 6:01 pm	1.05 1.38
June 11 Full Moon	12:02 am 12:32 pm	6.85 6.47	6:30 am 6:47 pm	0.78 1.19
June 12	12:48 am 1:18 pm	7.05 6.63	7:17 am 7:34 pm	0.56 1.04
June 13	1:34 am 2:05 pm	7.20 6.73	8:04 am 8:22 pm	0.41 0.93
June 14	2:22 am 2:53 pm	7.26 6.76	8:52 am 9:11 pm	0.36 0.90
June 15	3:11 am 3:43 pm	7.23 6.75	9:42 am 10:02 pm	0.39 0.92
June 16	4:02 am 4:34 pm	7.11 6.72	10:33 am 10:56 am	0.49 0.98
June 17	4:56 am 5:29 pm	6.93 6.69	11:26 am 11:52 pm	0.63 1.03
June 18 Last Quarter	5:52 am 6:26 pm	6.74 6.69	12:21 pm	0.78
June 19	6:52 am 7:24 pm	6.58 6.74	12:51 am 1:18 pm	1.05 0.92
June 20	7:52 am 8:23 pm	6.48 6.81	1:50 am 2:15 pm	1.01 1.02
June 21	8:52 am 9:20 pm	6.44 6.91	2:50 am 3:13 pm	0.93 1.07

Why does the Bay of Fundy have the highest tides in the world?

There are many factors that contribute to the Bay of Fundy having the highest tides in the world. The two most important factors are: the shape of the bay, and the seiche of the bay.

Shape

Looking at a map of the Bay of Fundy we notice that it is shaped like a funnel, it is very wide at one end and very narrow at the other. Also the Bay is very deep at the wide end and very shallow at the narrow end. When water flows into the bay or when the tide is coming in, the water will get squeezed up to create the giant tides of Fundy.



Seiche

A seiche is the natural resonance of a body of water and every body of water (lake, ocean, bay, etc.) on earth has a natural resonance to it. This resonance can be compared to a person rocking back and forth in their bathtub creating a "sloshing" of water from one end to the other. The time it takes for this natural resonance or "sloshing" to move from one end of the body of water to the other is dependant on its width, length, depth and shape. The time it takes for the seiche to "slosh" from one end of the Bay of Fundy to the other is exactly 6 hours and 13 minutes, the same amount of time it takes for the tide to come in. These two forces, the tide and the seiche, coincide to create the highest tides in the world. The seiche should not be confused with surface waves on a lake or ocean, these are created by wind.

How high are the tides in the Bay of Fundy?

The highest recorded tide in the Bay of Fundy was in Burntcoat, Nova Scotia, where they recorded a difference of 53.38 vertical feet or 16.27 metres! In the St. Andrews area, where the Huntsman Marine Science Centre is located, the tide rises anywhere between 20 to 26 feet or 7.92 metres. No matter where you are in the Bay of Fundy, it is always fascinating to witness how much the tide rises and falls every day.